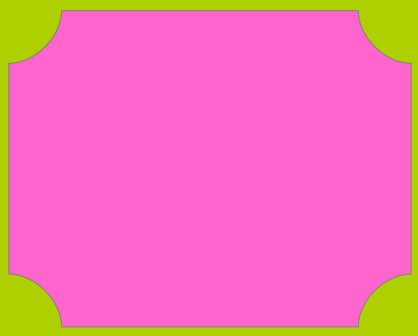
A.P. MARYUKHIN

INDETERMINACY IN LOGIC AND LANGUAGE



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1. Unity of Science. 2. Philosophy of Language. 3. Indeterminacy.

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Preface

This little issue I dedicate to all empiricists. It extends my previous book “Science and Language” and “History and Structure of Languages”. It also goes beyond my program of “The Unity of Science” and penetrates many aspects concerning indeterminacy in all branches of science and life.

I am in search of new scientific paradigm for language understanding. It claims new approaches and endeavors. I always try to remain in current trends of linguistics, although it demands much tension and attention. As a result, today the Krupskaya Scientific Library in Astrakhan has restricted my access to its departments because of a pandemic situation and other private disagreements. It pushes me to find other sources of knowledge. Yet I am not without fresh ideas and passion to further intelligent labor.

Astrakhan, 2021

§ 1. Historical Backgrounds

The 18th century is probably the period in the history of our subject that has been most neglected in relation to its importance for modern linguistics. In the philosophical-historical constellation of the Enlightenment, linguistic questions were raised that are also up for discussion in today's linguistics and continue to be intertwined with ideological problems, albeit under completely different conditions. We will first point to some more general aspects of the connection between language theory and worldview, especially in the French Enlightenment, and then to some of its more specific manifestations. In order to avoid repetition, we would suggest that most of the linguistic-theoretical questions touched upon in the following were the subject of a long and intensive discussion, in which well-known Enlightenment thinkers, such as Voltaire, Condellac, Diderot, Rousseau took part.

Important linguistic-theoretical points of view of the 18th century reflect a conflict that gained decisive importance for the development of Enlightenment philosophy: the conflict between a new experiential science program and an a priory theory of ideas, whose main representative was Descartes (1596-1650). Within the philosophical systems of Descartes and his opponents, one can say that it concerned the confrontation between rationalism and sensualism.

The dualistic-rationalist doctrine of Descartes and the sensualism of Locke (1632-1704) and his successors were the philosophical expression of two stages in the life practice of the rising bourgeoisie. Descartes' appeal to the powers of the human mind formulated the self-consciousness of the bourgeoisie towards scholastic philosophy, but his postulate of the two fundamentally different substances — spirit and matter — and in this connection his doctrine of native ideas of supernatural origin were an expression of adaptation to the prevailing religious worldview. The doctrine of the “native ideas” therefore challenged the criticism of the English and French Enlightenment in two ways: as a bastion of church dogma and as an obstacle to the historically necessary expansion of experiential science. Depending on the ideological position and the subject of the discussion, one or the other of these two aspects is highlighted. Descartes' dualism had transferred all mental activity to an incorporeal soul attached to the human body. It is the bearer of “native” ideas, independent of experience, which have a divine origin and are the source of assured knowledge, while the senses only convey an unreliable knowledge. For the theory of language, this doctrine gained importance by associating itself with the conception of a universal *a priori* reason, which, of course, did not originate with Descartes. In this view, language is merely an instrument of communication of a thinking that exists independently of it.

Thus, the contradiction between universality of thought and specificity of individual languages was raised in a way that presupposed a fundamental role of universal laws of thought for all languages and made it a preferred point of view of language consideration. Thus, the rationalist view suggested the deductive emanation of categories of thinking. Although the grammar of Port-Royal (1660) mainly continues the tradition of Renaissance grammar and Scholastic grammar, and Descartes' philosophy apparently owes no substantial suggestions, it is not incorrect to call it a rationalist grammar; for the principles of its conception of language, which is based on a universal raison, could be

reconciled with the rationalist elements of Descartes' philosophy.

While the linguistic repercussions of the rationalist component of Cartesianism have been pointed out several times, his mechanistic psychophysiology has so far received little attention in this respect. For Cartesian dualism, the bodies of all living beings were mechanisms, “machines” as it was then said, of which only the human body is distinguished by the assignment of an incorporeal soul. Language, as an expression of the thoughts of the soul, was therefore considered the external, by the body, characteristic of man in relation to animals.

Cartesian dualism thus led to the question of the respective share of the soul and the body in language. Consequently, the rationalist answer explained all linguistic meanings as conceptions of the soul, but the forms of language produced by the body and sensually perceptible as a matter of the “machine” and thus drew attention to the mechanism of language production. From the application of this side of Cartesianism to language, the hypothesis emerged that it must be possible to build *automata* that reproduce sounds of human speech. In the 18th century, this idea was pursued further and finally a “speaking machine” was constructed, which could articulate several words of different languages.

Theoretically even more important was the application of Descartes' mechanistic physiology to language soon after his death: the sounds of language, like the sensory perceptions in the brain, evoke mechanical “impressions”, which are perceived there by the incorporeal soul. Even if the speaker wants to name an absent object, he must evoke in his brain the “impression” of the designation. Finally, the usefulness of the brain goes so far that even purely mechanically the impression of an object is coupled with the impression of its designation. The application of Cartesian physiology to the physical conditions of language thus renders the assumption of an incorporeal thinking in favor of the expediency for thinking and speaking.

As early as the end of the 17th century, Locke, in his essay on human understanding (1690), had opposed the doctrine of the native ideas to the sensualist principle that all knowledge comes from sensual experience and also deals extensively with linguistic problems. In the originally concrete meaning of the designations of abstract concepts, Locke sees a confirmation of the thesis of the sensual origin of human knowledge, but without assuming a constitutive role of language for thinking. Leibniz already pointed to a dualistic relic in Locke's system by adding the following to the programmatic sentence *Nihil est in intellectu quod non prius fuerit in sensu: nisi intellectua ipse*. In fact, Locke had placed sensory perception as an external experience and *a priori* thinking ability as an internal experience at the beginning of all cognition and thus maintained a dualistic principle despite all criticism of Descartes. This is where the further development of sensualism by Condillac begins, whose philosophy gained considerable importance for the theory of language. With the help of a central role of sign theory and language, the mind itself is also traced back to the further development of sensory perception and thinking is explained as sensation transformer. Unlike Locke, language is assigned a constitutive role in the emergence and functioning of thought.

Thinking arises from the gradual process of mutual development of sensory sensations, linguistic signs and communication needs. The communication needs are awakened by the joint engagement of people with their environment, developed more highly by the use of signs and, in turn, place ever new demands on language. For two

such important problems as the origin of language and the relationship between language and thinking, this theory brought new points of view into the debate. Of particular ideological explosiveness was the problem of the origin of language: since language was regarded as the most important distinguishing feature of man compared to animals, the sensualistic question of the origin of language raised the question of the origin of man in a way that disregarded the irreconcilable difference between man and animal from a rationalist point of view. Thus, the doubt about the supernatural origin of language, which in any case called into question the biblical creation myth, acquired an additional sharpness.

Condillac expressly allows man's ability to think and speak to arise from a level of sensitivity and communication which even the higher species of animals possess. This gave new topicality to the observations on the forms of communication of animals, which had already been made in opposition to the conception of animals as purely physical, soulless *automata*.

The problem of the misuse of language, which was also raised again and again in the 18th century, belongs to the same theoretical scope as the problem of language-folk character. Locke had devoted several sections of his major philosophical work to the abuse of words. Sensualistic language criticism points out that the use of signs entails the danger of orienting thinking predominantly on the signs instead of on the things and thus making the words meaningless or giving them “false” meaning. From this point of view, the opposition of words and things was a buzzword repeated countless times. The postulate of a constitutive role of language for thought gave this problem an even greater theoretical weight.

For if language makes thinking possible in the first place, by providing signs for the fixation and handling of ideas, then, in addition to the immeasurable gain, there are also the greater dangers associated with it: the routine of the use of language can lead to signs only being repeated, without any real ideas being associated with them at all. Real ideas can only be the result of an analysis of reality. The neglect of this analysis can lead to incorrect and, finally, even completely imaginary word meanings. Again and again, therefore, man must turn to the analysis of the representational world and the ideas about which he speaks, and precisely determine his ideas in order to provide them with immeasurably understandable signs. As to Condillac's sensualist predecessors, the misdirection of thought through the incorrect use of language is not limited to the individual process of cognition, but to social communication, in which language can be used unconsciously or even with full intent to mislead. To make language an instrument of true knowledge is all the more important an obligation than the “intercourse of men among themselves”, that is, in modern words, social communication, which is the chief source of human knowledge. Rousseau is the most radical critic of political language abuse. The very emergence of property and social inequality occurred under the misuse of language. And in modern society, according to Rousseau, that part of society that has risen above the people builds a world of appearances with the help of language in order to disguise reality and assert one's own interests.

Even the judgment on more specific lexical problems, such as questions of synonymy and neology, i.e. the creation of new words or word meanings, was not independent of worldview development. In the 18th century, the theoretical understanding

of synonyms as meaning-like words developed, with the help of which it is possible to grasp the various aspects of a term or to take into account the specificity of a communication situation. The word nuance, whose use only began to unfold in the 18th century, has rightly been referred to as a characteristic catchphrase of the sensualist view.

In the 20th century, therefore, a wave of synonymic dictionaries began for the first time. This results in advocating the need for new words or word meanings, including in the language of literature, as well as a broad theoretical and practical opposition to the definitive fixation of linguistic norms, up to advocating the flexibility and even the mutability of grammatical rules. Finally, some remarks on grammar theory and language methodology.

Language teaching should therefore start from the individual and the sensually perceptible in order to impart knowledge and develop intellectual abilities. The rationalist view that the most important rules of grammar are anchored in native thought, on the other hand, concluded that language teaching must make these rules conscious by emphasizing grammar. In contrast, the practice was reset on the basis of original texts. Especially in Latin lessons, it was assumed that the grammatical rules of knowledge needed only to be extended by vocabulary skills in order to enable students to produce texts. Hence the overemphasis on memorizing grammar rules and vocabulary, which was still practiced for a long time in language lessons.

The sensualist methodology, on the other hand, called for the learning of languages on the basis of original texts and, if we translate this demand into modern terms, of communication situations that were as natural as possible. Sufficient linguistic experience is necessary to make the grammatical rules conscious at all. Even the problem of sentence construction stood in the field of tension between rationalism and sensualism. From a rationalist point of view, the order subject-verb-object was explained as a “natural order” of thoughts, from which, however, languages, as a result of their use in the physical existence of man, deviate more or less, thereby losing “clarity”.

This often repeated point of view was countered by the fact that the rules of sentence construction did not arise from a priori laws of thought, but arose in the historical course of social communication, which took place as a mental and linguistic processing of the environment of man. Different languages have developed different means of identifying syntactic relationships. Each language can express syntactic relations in a “natural” way using its own means.

This historical explanation correlated with a new understanding of the relationship between grammar and language activity. The contrast between reason and usage, which has been emphasized since the 17th century, reflected the rationalist dualism of incorporeal thinking and corporeal experience in the form of language theory, which is also reflected in the rationalist view of the relationship between grammar and use of language, or in a sharp reduction of grammar and rhetoric. The sensualist point of view, on the other hand, focuses on the function of grammar in different communication situations, for different communication purposes and speaker points of view, i.e. the flexibility of grammatical rules in the use of language.

Numerous parallels between the preceding explanations and questions of modern linguistics are so obvious that it required reluctance to dispense with them. The mere reference to parallels with today's topicality of the relationship between system character

and activity character of language, or to the juxtaposition of “competence” and “performance” would run the risk of being superficial. The fact that these parallels exist indicates how important it would be for the self-understanding of modern linguistics to gain insight into the continuity and discontinuity of the continuation of linguistic-theoretical ideas of the Enlightenment since the end of the 18th century.

The continuation in the transformation of these ideas or the renunciation of them could not take place independently of ideological positions, although since the institutionalization of linguistics as a scientific discipline, language theory is often no longer as obviously intertwined with philosophical points of view as in the Enlightenment. Of course, the ideological aspects have also changed.

The consideration of the difference between phylogenesis and ontogenesis of thought and language has transformed the former ideological opposition between the acceptance of native ideas and sensualist theory today, in part, into the world-philosophically no less relevant linguistic-theoretical problem of the relationship between biological and social factors. The language discussion of the Enlightenment underlines that language-theoretical points of view can be not only an expression, but an integral part of ideological positions.

§ 2. Linguistic Foundation of Logic

Human thinking is mostly, but not always, accompanied by words. In associative experiments, for example, one experiences quite often that the idea clearly appears before the word designation. On a geometric figure, we can make long and intricate reflections without a word accompanying them. So there is also a speechless or, as one can say, an unformulated thinking. By most people, however, its occurrence is limited to those thought processes which take place immediately after present sensations or vivid images of memory, and is to be regarded as an exception here as well.

More difficult is the question of whether thinking occurs without all the “signs” (words are a special kind of signs). Leibniz has denied this and considers, for example, the geometric figure, to which a mathematical thought is linked, also as a sign, while it is apparently itself the object of thought. Introspection also seems to me to speak against the absolute denial of a signless thinking. In this view, we have to think of language as a complicated structure composed of various components. The important role is played by the acoustic word component, i.e. the acoustic memory image of the heard word. Above all, thinking is continuously accompanied by such word-sound images. In addition, there is also a slight co-innervation of the speech muscles, which is too weak to lead to an audible utterance of the words, but we can still speak through so-called kinesthetic sensations. In special cases, the visual perception of the written or printed word and the innervation of the hand muscle corresponding to the writing is added. Often all components of the word are summarized as “word concept” and the latter is contrasted with the “object concept”, i.e. the word meaning. However, this term is not entirely correct, since motor speech innervation is not an idea.

The meaning of a word or other sign therefore psychologically coincides entirely with the complex of ideas directly linked to the word concept. The relationship between

the word and the designated complex of ideas (in the borderline case: a simple idea) is nothing other than the fact that such a complex of ideas is usually linked to the word by many people, namely those who are powerful in the relevant language. In everyday life, we often refer to this fact of frequent connection and thus the potential connection as “meaning”.

The act is identical with the connection of the object idea (regardless of whether it is individual or general, vivid or unanswerable). Secondarily, with frequent use of a word, there is a fusion of the word conception with the complex of the object conception, a fusion which corresponds entirely to that between the partial conceptions of any other composite conception. If one wants to describe this fusion as a unit of experience, then there is nothing wrong with it in itself, but one must not believe that it is something specific or new. If Mr Husserl distinguishes an optional “meaning-fulfilling” act in addition to the meaning-giving act, we can only understand this as the optional connection of illustrative representations (in the case of general representations). The meaning of words must, of course, be strictly distinguished from the meaning of ideas previously discussed.

The main advantage of language development, and therefore also the main cause of it, lies in the fact that we can communicate our psychic processes to each other. In particular, through language, we are able to “tie our thinking to the general thinking” of other people (W. Humboldt). In addition, however, the linguistic accompaniment of thought gives us certain other advantages, which have nothing to do with the communication of our thoughts, but promote the activity of thought as such. Most of our ideas have been set apart, emerged from extremely numerous partial ideas. Psycho-physiologically, the unity of these composite ideas is based on the continuous linking of the involved elements by more or less 'polished' association paths. The word, in particular the acoustic word concept, is now representing a unit for such an association complex. It not only enables rapid communication to others, but also facilitates the thinking activity. It plays in this relation the same role as in mathematics the letter *qp* or *S*, which we introduce for a complicated mathematical expression. Such abbreviations do not make mathematical thinking possible in the first place, but they do make it extraordinarily easier.

Therefore, if language is an almost regular and very meaningful companion of the thought process, one must not think that there is an absolute parallelism between speech and thought. For example, it cannot be said that in the sentence “This rose is more beautiful than that”, in the same order and at the same speed, we first think “this”, then “rose”, then “is”, etc. Rather, the order in the sentence is shifted in relation to the sequence of thought, separate ideas are often combined in one word, uniform ideas are broken down into two or more words, the words lag behind the ideas, individual ideas remain, because their addition is self-evident, completely unexpressed (so-called ellipses). It can almost be said that in the formation of the sentence a transformation of the thought (judgment, etc.), adapted to the language and the word material just presented by the constellation, takes place into a new series of ideas, which now finds linguistic expression. This inserted series, however, usually does not come to our consciousness as a separate entity. One must therefore be very careful to draw a direct conclusion from the linguistic formulation as to the course of thought. Above all, it must also be taken into

account that the individuals do not in any way associate the same idea with the same word.

Long before Mr Steinthal first clarified the close relations between speech and thought as a psychological process, the doctrine that language and logical thought run in parallel or are almost identical was everywhere. Not only actual thinking, as it is the subject of psychological study, but ideal thinking should find its immediate expression in language. From Aristotle to Humboldt, this view prevailed with a few exceptions; it was only usually not expressed so harshly, since one rarely made a sharp distinction between the actual thinking of psychology and the ideal thinking of logic. In this view, grammar almost completely coincided with formal logic. Logic should relate to language teaching as mathematics should relate to physics. In spite of the psychological-historical direction of general linguistics initiated by Mr Steinthal, the old logical conception has not completely disappeared even today. And indeed, linguistics has relations not only with psychology, but also very significant and direct with logic.

Apart from the fact that language has thus developed under the influence of logic, it also enters into closer relation to logic through another fact. In a certain contrast, language acquires a meaning for logic that is remotely similar to that of mathematical sign language for mathematics. With all this state of affairs, it is very understandable that it has often been said that linguistic expression is indispensable, even if not for actual thinking, but for logical thinking. Even if this claim goes a little too far and yet logical thinking without language also occurs, it remains true that logical thinking has its natural and most important aid in language.

Two Systems of Logical Views

Leibniz' system	***Logical necessary truths***	***Factual truths***
Poetics (Mallarmé & Valéry) (1880-1920)	Poetic meaning	Its performance
Vasiljev's imaginary logic (1910-1912)	Law of contradiction as law of thought	Law of contradiction as law of reality
Language system (Trubetskoy's phonology) (1939)	Opposition of phonemes – "logical"	Opposition of phonemes – "factual"
Generative grammar (after Chomsky) (1962-1972)	"Competence"	"Performance"
Literature system (nowadays)	Performance (as a thought system)	Text

§ 3. Logically Ideal Language

The perfection of language for the purposes of logic and, moreover, the creation of a logical language of its own is suggested by the fact that the real languages are comprehensible only to individual peoples. After all, the use of Latin provided a remedy for this, and indeed, up to the first centuries of modern philosophy, a large part of the philosophers and especially the logicians wrote most of the works in Latin. Another moment, however, pushed directly for the formation of a logical ideal language: the

inadequate adaptation of all languages, including Latin, to the special needs of logic. Such a specifically logical language was thought to require that it simplifies the linguistic signs and expresses the composition of the ideas by combining the signs for the simple ideas (elementary ideas).

We encounter the first attempts at a logical ideal language in the historical section of Lullus. Then followed the works of Wilkins, Dalgarno, Kircher and Leibniz. The latter originally wanted the elementary terms (*termini primi*) by dot signs, their relations by lines, etc. and later came to the idea of an "Alphabetum cogitationum humanarum" and an "Analysis axiomatum". With this he already connected the basic idea of mathematical logic. On the other hand, he also considered it necessary to reform the previous signs for the numbers. In accordance with the general principle, the character should also indicate the composition here; for example, a character should be selected for 8, from which it is readily apparent that $5 + 3 = 8$ and $2 \cdot 8 = 16$. The ideal sign language should be so general that it also includes mathematics, not just the mathematical signs transferred to thinking.

The Leibnizian plan was partly resumed by Mr Ploucquet. However, the latter was limited to express certain general relations by letters or signs. Thus, for example, *O omnitudo* should mean *positive sumta*, *N omnitudo – negative sumta*, *Q vel q – particularitas*, *A B – subjectum A cum praedicato B, A — B* is *A est B, A > B* is *A non est B, N A* is *B nullum A est B*, etc.; *i* for the particularly affirmative, *e* for the generally negative and *o* for the particularly negative. The Ploucquet's symbolism completely dispensed with signs for the content of the ideas, it remained quite formal. In fact, with this restriction, Ploucquet apparently did the right thing. The plan of a material sign language, as envisioned by Leibniz and his predecessors, is for a long time an utopia, in that it presupposes that philosophy has already reached the end of its path and has completed the decomposition of all concepts into the last elementary concepts. Since there is no prospect of this in the foreseeable future, the logical ideal language in a material sense must therefore be dispensed with almost completely, at least for the time being. In more recent literature, this point of view has usually been taken and only the formal relationships expressed by special symbols. Thus, for example, Fregean terminology is essentially limited to expressing intellectual relations through symbols. The individual ideas are denoted by letters for abbreviation, but without the intention of saying anything about their content. A means, for example, an arbitrary, quite indeterminate idea (but, of course, always the same in the course of an investigation). So the letters here have a similar meaning as in mathematics.

A substantial difference remains between the logical and the mathematical relationship symbols only insofar as the mathematical symbols are essentially limited to quantitative relationships. Logic has therefore either created its own symbols according to the analogy of mathematics or, neglecting the difference just highlighted, simply transferred the mathematical symbols to logic under certain reinterpretations. In the former case, too, the reference to mathematics is so narrow today that symbolist logic is to be discussed together with mathematical logic, insofar as the discussion is not to be referred to the special logical sections at all.

The expressed renunciation of a material symbolism is not complete, insofar as logic is often forced to adapt the linguistic signs for the contents of the imagination to their

purpose, at least here and there, without any claim to going back to the basic concepts. The fixing of word meanings by definitions (cf. the logical special section) is not sufficient for this purpose, since, as the history of philosophy everywhere teaches, the influence of popular or other secondary meanings is not eliminated even by the most correct definitions and, moreover, each definition again introduces numerous new, equally ambiguous words in need of definition. The re-formation of words, which is unavoidable anyway when it comes to new terms, can also give considerably greater guarantee for the symbolic fixation of a word in old terms. If the newly formed word is borrowed from a relatively international language, such as Latin or Greek, general intelligibility is ensured at the same time. Nevertheless, defects are also liable to this procedure. Apart from the fact that it does not entail any abbreviation, the newly formed words are very often devalued again in the use (also in the scientific) by secondary meanings and reinterpretations inserted every day. Words such as “ideal”, “real”, etc. have become so ambiguous that they are almost even more dangerous than the popular words of everyday life. In this situation, philosophy and in particular also logic helps itself by introducing symbols — letters with indices, numbers, etc. — also for individual concepts (normal ideas) determined in terms of content, at least for a certain investigation or series of investigations. Thinking is thereby protected from phrases, misunderstandings and sophisms, and this protection is not bought too dearly by the difficulty of understanding such signs; neither philosophy in general, nor logic in particular, is intended for shallow and sluggish minds. At the same time, logic thereby gains a considerable shortening of the thought process itself and its representation, a shortening that at the same time involves a promotion. By the way, logic in this procedure takes only one path, which mathematics has long entered. The latter, too, is not limited to purely formal signs, but also introduces material signs everywhere for very similar reasons. The fact that such signs also best meet the requirement of international comprehensibility does not require emphasis.

It also seems to me not entirely impossible that, within narrow limits, logic could here and there improve the individual national language somewhat in a logical sense, even for general use. Languages are, in general, the natural results of the development of the people; but this does not preclude the possibility of a single science attempting to intervene artificially in an expedient direction (as has often happened in the field of religion and custom), of course subject to the final decision of the general use of language. Thus, for example, the German word “or” is logically ambiguous in the most disturbing way; namely, it soon does not involve the mutual exclusion of the connected terms (— either — or).

§ 4. Language of Logical Empiricism

In order to characterize the function of theoretical terms, the structure of an observation language must first be explained. Only those sentences which do not contain any quantors are allowed to be there. A certain logical apparatus, e.g. x (x = x), is presupposed in the formulation of an observation language.

Whatever the difference between observational terms and theoretical terms, possible progress within knowledge is conceivable only if our theoretical language is explained by

semantic inferences. Even in contrast to the language of observation, the meaning of the theoretical terms is peculiarly theory-related. By implicit definition, their meaning gradually arises. This leads to the conclusion that in different theories the same theoretical terms acquire different meanings. The relevance of this fundamental openness/ indeterminacy lies in the fact that a change in the meaning of the terms from theory to theory can result, which in no way needs to be an expansion of meaning, i.e. a progress of knowledge.

We say that the relevance of theoretical terms is based on their function of being cross-theoretical according to an indeterminacy. At this point, attention should be drawn to a modal relationship, among other things. Suppose that A or its negation ¬A are propositions which cannot be derived from a completed theory T. Both sets are initially irrelevant to T. However, only as long as TA is not claimed. The claim that TA is valid beyond T is by no means irrelevant. This is because it already uses theoretical terms, which should be relevant for both T and A. Otherwise, TA could not be formulated at all.

Thus, we note that the relevance of theoretical terms lies precisely in formulating TA or T∧A. Already this argument is enough to say that theoretical terms can never have definite meaning. Mr Radermacher asks: “What is the logical place for the formulation TA? Is the validity of propositional propositions relative to T or independent of T? Then what does the conclusion of a theory mean? Where is the logical place for reviewing the formulation TA?” If T is allowed and A is allowed, this means: E(A)∧E(T). Immediately it is clear that the conjunction E(AT) from E(A) does not follow E(T). E(AT) certainly implies E(A)∧E(T), but not vice versa. The statement E(AT) is therefore different in its information content from that of E(A)∧E(T); the information content may, incidentally, be greater or less than that of E(A)∧E(T). So what a completed theory would have to show is that no predicate can be found that is adjunctable to the theory in question. Otherwise, amendment is not excluded. This amendment concerns both the extension of meaning and the extension of meaning.

This already poses the problem of the identity of the information content during transformation. It was pointed out at the outset that several models have emerged in the course of the discussion about Mr Kuhn. There is a talk of subordination or approximate subordination of theories among themselves; furthermore, the attempt is made to identify the infalsifiability of a theory; in turn, it is necessary to explain the phenomenon of the death of knowledge, to discuss the problem of the incommensurability of theories, to explicate discontinuity or continuity as forms of the labyrinth of knowledge. The concepts of family similarity and evolution also have their relevance in this context.

What stands out in this catalogue of interpretation possibilities is the fact that all proposals are reactions to a phenomenon which is very well defined with the predicate indeterminateness. Even when theoretical terms are allowed, an indeterminacy is assumed that does not appear to be possible. This applies both to the case where such theoretical terms appear in the context of a theory, i.e. are an essential component of a theoretical language, and to the case where theories are excluded. Unfortunately, this radical theory of world development was only recognized very late in the theory of science and, in my opinion, still not properly assessed in its scope. The logical empiricists of the Vienna circle (Carnap, Hempel and others) conceived a theory model based on a strict separation

of theory and experience. They divided the vocabulary of a theory into theoretical and empirical terms (= observation terms). Observational terms refer to (directly) observable qualities, such as the terms “red”, “hot”, “longer than”, “bird”. In contrast, theoretical terms have no direct empirical meaning and can only be understood through the context of the theory. Examples of theoretical terms are “electron”, “energy”, “electric field” or “consciousness”.

This separation raises numerous problems, which primarily concern the theoretical terms, which is why one speaks in this context of the problem of the theoretical terms:

– How do theoretical terms relate to observational terms? Can theoretical terms be defined by observation terms, for example?

– Is it possible to distinguish strictly between theoretical terms and observational terms? Is there a strict criterion that allows to decide whether a given term is theoretical or empirical in nature?

– What is the methodological function of theoretical terms within a theory?

– Are theoretical terms superfluous, i.e. can they be easily eliminated from theory?

– Do theoretical terms have a referential function? Can theoretical terms be ascribed an empirical meaning or are they merely instrumental?

– Do theoretical entities have a different ontological status than objects of observation?

This last set of questions has led to a dispute between realists and instrumentalists. Realists insist that theoretical terms refer to real existing entities, while in the opinion of instrumentalists they have no referential function and are therefore superfluous. But if theoretical terms do not refer, then there is no reason to assume the existence of theoretical entities.

The empirical two-stage model and the associated separation of theoretical terms and observational terms proved their untenability. No valid criterion could be given which distinguishes observation terms from theoretical terms. Moreover, it became clear that every concept of observation is “loaded by theories” and the above separation thus becomes questionable.

There are two possible ways out of these difficulties: either one saves empiricism by looking for a new criterion for distinguishing theoretical and non-theoretical terms, or one finally abandons the dichotomy “observable – theoretical” and admits that all terms are theory-dependent. The first path was taken by Mr Sneed with the “structuralistic theory of science”, while the second path leads to a holistic theory model.

The structuralistic theory of science believes that it is possible to solve the problem of theoretical terms with a new criterion for the theoreticity of terms. Theoretical terms are distinguished by the property that in their measurement the whole theory, in the context of which the terms occur, must already be assumed to be valid. All other, non-theoretical terms “escape” this methodological circle because they are “anchored” in deeper, firmly established theories and their measurement is therefore unproblematic. This study deserves special attention because the structuralistic theory of science currently represents the most influential school of scientific theory.

The examination of the structuralistic theory of science should not be an end in itself of this work, but rather the search for possible alternatives should also form a focus of the investigation. Since the difference between theoretical and empirical terms is in reality a

smooth transition and is not marked by a sharp boundary, a theory model must be developed that does not require the criticized dichotomy of the scientific language, but that can nevertheless explain how theories can be tested on experience. Furthermore, the theoretical model must also be able to describe phenomena of theoretical dynamics and the history of science, such as the property of the immunity of theories, which was controversially discussed in the theory of science in the seventies in particular.

The other aim is to represent a holistic theoretical model based on the ideas of Mr Duhem and Mr Quine. Unfortunately, they limit themselves only to incomplete sketches, so that the holistic theoretical model has not been further developed. Therefore, the task is to put holism on a solid foundation.

Mr Duhem and Mr Quine assume that a theory cannot be confirmed or rejected as a whole and that individual hypotheses cannot be tested in isolation. According to Mr Lakatos and Mr Quine, within a theory one can distinguish a hard core and a periphery surrounding the core (protective belt), but the transition between the two areas is fluid. In addition, the holistic theoretical model can be clarified and expanded by specifying the theory core and the periphery of a theory in more detail: “The core contains the fundamental laws of theory, while the periphery consists of system-specific phenomenological theories and models that establish the “contact” with empiricism. This structure of theory explains the extensive immunity of theories to conflicting experiences, since in the case of a contradiction between theory and empiricism”.

According to Mr Popper, falsified theories are completely abandoned and replaced by new theories; old theories are overthrown by revolutions or their followers simply die out. In the holistic theoretical model, on the other hand, theories can continue to exist as special or borderline cases of new theories even after a scientific revolution and continue to serve well. There is no strict alternative between immunization (“normal research”) or revolution (= paradigm shift). From a holistic point of view, paradigm shifts represent extremely rare special cases of changes in the theory core and therefore do not have the central importance attributed to them by Mr Kuhn. This close connection between theory structure and theory dynamics speaks for the performance of the holistic model.

Above all, this new approach offers a middle ground between orthodox representationalism (theories as images of reality) and an extreme relativism, as represented, for example, by Mr Feyerabend, who denies any scientific progress. Mr Sneed and Mr Stegmüller deal primarily with physical theories and in particular with Newtonian mechanics. A philosophical examination of the structuralist theory of science must follow this path and therefore also deal with the axiomatic structure of Newtonian mechanics. Special mathematical or physical knowledge is not required. This specific choice of case studies does not restrict the scope of the theoretical models discussed here.

§ 5. The Empirical Model of Science

The success of modern science is essentially based on the fact that it constantly introduces new invisible entities, which are supposed to explain the observable phenomena. Already Democritus attributed the physical properties of substances to the existence of atoms, of which all bodies are composed. According to Democritus, these

material elementary building blocks have different shapes and can combine in various ways to form complex aggregates, resulting in the diverse macroscopic properties of matter, such as structure, density and strength. Every change in the visible world is merely an expression of the mechanical motion of atoms; matter arises and passes away through the connection and separation of atoms. The atoms themselves are immutable, indestructible and imperishable. What changes are only the changing constellations of atoms.

The term “atom” is a typical example of a theoretical term. It refers to non-observable objects and its meaning is only understood through the context of the theory. Nevertheless, atoms should be related to observable properties of matter, so theoretical terms should be reducible to observable terms. This example shows what power theoretical terms can have. Theoretical terms establish relationships between observable phenomena, thereby reducing the complexity of the visible world. The history of the natural sciences provides many examples of the success of this strategy: think, for example, of the phlogiston theory in chemistry, in which a mysterious substance was postulated, which was supposed to explain the combustion of substances. In physics, the theory of electromagnetic fields could be called or the revival of atomic theory at the beginning of the 20th century. But the reality of the theoretically postulated entities (phlogiston, fields, atoms) remained controversial. Thus, the Democritus nuclear model is now considered obsolete and has been replaced by improved models.

The importance of theoretical terms was first recognized by the logical empiricists of the Vienna circle (Carnap, Hempel). The empirical model demanded that all meaningful non-logical concepts of a theory should be traceable to the "immediately given". Here it is necessary to clarify: 1. What are “meaningful” terms and 2. What is the “given”?

Positivism excluded all non-descriptive metaphysical concepts from the field of scientific language as “meaningless”. In fact, only those propositions which are reducible to observation propositions, i.e. which can be inferred from them by deduction or induction, were regarded as empirically meaningful. A statement can only be empirically meaningful if the facts expressed in it can in principle be verified by experience. Mr Schlick brought this empirical criterion of meaning to the short doctrinal form “The meaning of a sentence consists in the method of its verification”. The meaning of a sentence must therefore be demonstrated on the basis of observational facts. Empirical data form the solid foundation that the building of science has to bear.

The phenomena can no longer be questioned further epistemologically. They are the “given”. Mr Carnap interpreted the “given” as psychic phenomena, more precisely as the self-psychic, which is immediately present to my consciousness. In his book “The Logical Construction of the World” Mr Carnap claimed that it was possible to trace all meaningful concepts back to sense qualities and their relations by logical definitions. The whole physical and physical world is therefore based on sensory data.

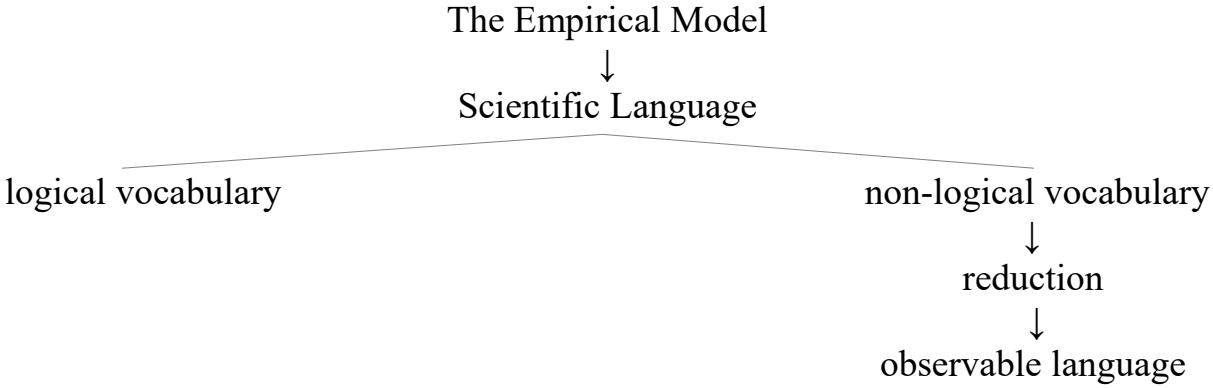
In contrast to the strict phenomenalism of early Mr Carnap, Mr Neurath pursued a physicalistic approach: the empirical basis of scientific theories is formed by so-called “protocol theorems”. Each perceived event can be recorded in the form of an observable statement, indicating the place and time. From the protocol sets, hypotheses and laws can then be formed by inductive generalization, which in turn can be checked by new observations.

Scientific propositions must therefore be verifiable and have an empirical content. Empirical philosophy can be summarized in two basic theses:

1. The language of the natural sciences can be constructed in such a way that it contains only descriptive terms interpreted by reference to experience.

2. All true scientific claims can be substantiated by observations and only by observations.

For the empirical theory of science, this has the consequence that the language of science breaks down into a logical and a non-logical vocabulary, whereby all non-logical terms must be explicitly definable by observable terms. Theoretical terms, such as "electron" or "wave function", must be unambiguously interpreted and defined by observable terms.



The positivistic theory of science demanded a strict logical reduction of all concepts to terms of observation. But it was precisely this high standard that empiricism set that was unfulfillable. Paradoxes could be derived that could not be eliminated within the framework of the empirical model.

First, Mr Hempel and Mr Goodman discovered the paradoxes of induction, which discredited the inductive process. Mr Carnap then found that there are terms that escape logical definition by observational predicates. These were so-called "dispositional predicates". In psychology, dispositional predicates are known as predispositions, abilities, habits or inclinations, which denote characteristics of a man, but as such are not directly observable, because they manifest themselves only in certain situations as behaviors. Examples of dispositional predicates are "intelligent", "choleric", "stingy", etc. Also in physics, and this makes the matter interesting for the theory of science, such dispositional predicates occur: e.g. "magnetic", "elastic", "water-soluble", etc. Materials only show these properties when certain experiments are made with them. For example, a piece of sugar does not show its water solubility until you throw it into the water and watch the sugar slowly dissolve. Thus, what can be observed is not the solubility in water itself, but only the behavior of sugar in water. For the predicate "water-soluble", an operational definition is then appropriate: "x is water-soluble iff the following applies: if *x* is added to the water, then *x* dissolves. In formal notation: W (x) = (A(x)>B (x)).

Now, however, we know from the laws of classical logic that an implication is true even if its presupposition is false, i.e. (A(x)>B(x)) is true if A(x) is false. In other words, an object is water-soluble even if it is not put into the water. Therefore, any item that is not in the water would be water soluble! This paradox cannot be eliminated either by using a different definition of "water-soluble".

According to Mr Popper, each term contains unspoken theoretical prerequisites. For example, the meaning of the term “water” is determined by the lawful behavior of this substance. (e.g. “water is liquid”, “water is translucent”, “water boils at 100° C”, etc.) In any set of observations, universals are necessarily included that point to a broad theoretical context.

The contextual dependence of concepts is also closely related to the theory-loading: words have no meaning in isolation. They only acquire meaning in the context of a language or theory. Any description of a fact depends on some theory. Certain terms can only be understood in terms of a scheme of cognition or a theory. For example, the term “mass” is understandable only within the framework of a physical theory, and therefore depends on the theory being considered. The term “mass” also occurs depending on the theory, e.g. in terms of Newtonian mechanics.

According to Mr Sneed, in Newtonian mechanics, force and mass are theoretical terms, while place, time, and speed are non-theoretical. In classical mechanics, forces can only be measured if the second Newton axiom $F = m \bullet a$ is assumed to be valid. For the unit of force 'Newton' is defined by reference to this very law: 1 Newton is the force F which gives acceleration $a = 1\ m/s^2$ to a body of mass $m = 1$ kg. Therefore, the force in the sense of Sneed is a T-theoretical term.

This suggests the assumption that Newton's second axiom is not a genuine law of nature at all: it is neither verifiable nor falsifiable. It cannot be empirically verified simply by measuring the mass, accelerating force and acceleration of a body and verifying Newton's basic law by the result of this measurement. Because when measuring the force, this axiom is already assumed to be valid.

The interpretation of Newton's second law has repeatedly led to the dispute between empiricists and conventionalists. For the empiricist, the second Newtonian axiom is a natural law and therefore empirically verifiable, while for the conventionalist it represents a proposition without factual content.

The Newtonian axioms of classical particle mechanics are:

1. Every body remains in its state of rest or uniform rectilinear motion, unless it is forced by the action of external forces to change this state.

2. The change of impulse is proportional to the total force which a body experiences; and this change takes place along the straight line in which this force acts.

This is the well-known law of motion – “force is equal to mass times acceleration” ($F = m \bullet a$), where force *F* and acceleration *a* are vectors acting in the same direction. The expression on the right side of the equation is also the “change of momentum” when the mass m is considered constant: $(m \bullet v) = m \bullet a$.

3. To every effect there is always an equal counteraction, or: the mutual effects of two bodies on each other always have the same amount, but are directed in the opposite direction.This is the interaction principle *actio = reactio*. (Quoted from W. Stegmüller)

For over two centuries, Newtonian mechanics was the only physical theory that existed in an axiomatic form. The three laws of motion represented, in the opinion of the time, a complete description of all natural processes, because it was believed that nature obeys exclusively mechanical laws. Newton's axioms shaped a philosophical worldview. From them, the entire physical knowledge known at that time “more geometric” could be deduced, which elevated Newtonian mechanics to the rank of an ultimate truth.

It became clear that the three axioms were by no means logically exact, rather Newton became entangled in a series of circle definitions. Thus, for example, the mass, referred to by Newton as “quantitas materiae”, is defined in the Principia as the product of density and volume. But how the density of a body should be measured independently of its mass was not explained by Newton.

Another disadvantage of Newton's formulation is that the three axioms are not independent of each other, since the 1st axiom (law of inertia) proves to be a special case of the 2nd axiom (law of motion): according to the law of inertia, a body is in a state of rest or uniform motion when no external forces act on it. But this statement is already contained in the 2nd axiom (F = m • a). Namely, from it follows: if there is a body at rest or moving at a constant speed $v = const.$, then its acceleration is $a = 0$, and therefore no external force acts on it. And vice versa: if the sum of all acting forces is equal to zero, the integration of the equation of motion F = m • a results in the body moving rectilinearly and uniformly (or it is at rest: v = 0). Thus, the first axiom is actually superfluous, because it does not contain any additional information.

The third point of criticism concerns the empirical verifiability of Newtonian axioms, and this brings us back to the problem of theoretical terms. The question has repeatedly been raised whether the statements made in the three axioms are at all independently verifiable or whether the axioms are merely implicit definitions of the terms contained therein. It is claimed that the second Newtonian axiom alone has no real empirical content, since every force measurement and mass determination already presupposes its validity. These problems were already known to many physicists before Mr Sneed. If one assumes that the law of motion is in fact not a verifiable statement of fact, but a hidden definition, then three different interpretations are possible:

1. The law of motion is a definition of force. This view was held, for example, by Mr Kirchhoff and Mr Mach.

2. A second possibility of interpretation explains the concept of force as immediately understandable, since it is composed of intuitive ideas, such as muscle power. This view was held, for example, by Mr Sommerfeld.

3. Another variant of interpretation considers Newton's second law as an implicit definition of mass and force.

For Newtonian mechanics, the following picture of theory is valid:

	Force	***Velocity***	***Time***	***Length***
Newtonian mechanics	theoretic	non-theoretic	non-theoretic	non-theoretic
Newtonian kinematics	-	theoretic	non-theoretic	non-theoretic
Space-time-geometry	-	-	theoretic	non-theoretic
Euclidean geometry	-	-	-	theoretic

Another example of theoretical model is that of Maxwell.

Maxwell's Equation
(generalized electromagnetic laws)

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Theoretical Model of Electromagnetic Field

Faraday's laws for electro-magnetic induction	Coulomb's law for charges	Coulomb's law for magnetic poles	Oersted's laws	Ampere's laws	Law of electro-magnetic induction	Ohm's law Joule's law	Electromag-netic theory of light as consequence of Maxwell's theory
Faraday's model of electro-magnetic induction	Model of inter-action between charges	Model of interaction between magnetic poles	Models of interaction in magnet	Models of force interaction between gases	Faraday's model of electro-magnetic induction	Corres-ponding models	
Electrostatics		Magnitostatics and interaction between steady-state currents			Electro-magnetic induction	Current conduc-tion	

Faraday-Maxwell's Picture of Physical Reality

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Synthesized Theoretical Material

Electrostatics Magnitostatics Electromagnetics Steady-state current

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